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THE CARE AND FEEDING OF MAGNETIC TAPE

Discussion of the physical properties of tape as well as the advantages and limitations of tape as a record keeping vehicle.

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The program this morning, as you noticed from the flyer, will be "The Care and Feeding of Magnetic Tape." The discussion will be on the physical properties of the tape as well as the advantages and limitations of the tape as a record-keeping vehicle. Our first speaker will be Mr. Robert G. Devitt. Mr. Devitt is a native of St. Paul, Minnesota. He is a graduate of the University of Minnesota and after serving two years with the Air Force, he joined Minnesota Mining and Manufacturing Company. He has been with 3M in various capacities for the past ten years and is presently a Field Manager of the Magnetic Products Division. Mr. Devitt will discuss the manufacturing of magnetic tape.

Robert G. Devitt
3M Company

Thank you, Mr. Humphrey. First I would like to express the appreciation of 3M Company for the opportunity to participate in your conference here on "The Care and Feeding of Magnetic Tape." What we have this morning is a film strip which we put together for you to show how magnetic tape is made. Looking at the manufacturing processes, we will be seeing four types of magnetic tape made. The first is sound recording tape which is used to record the voice and to record music, and this is the first application for which magnetic tape was developed. The second type of tape is video tape. Video tape is used to record pictures. I believe you have all seen it on your television screens. We think in the next few years that video tape will be used extensively in the home as well as in industry. The third type of tape that will be seen is what we call instrumentation tape. This tape is used to record analogue or continuous data from remote areas such as satellites. The fourth is the tape that is used as an input and output device and as a storage device in computers. We call it computer tape.

This morning we would like to give you an idea of the critical nature of the process and of the quality control used to make computer tape that is required to be able to write and read more than one hundred and sixty million discreet bits in one reel of tape, discreet pieces of information on one reel. We know it is a requirement that the tape be free from errors, so that the computer can operate at maximum efficiency. In manufacturing a magnetic tape we strive to make a tape that is perfectly free from flaws. So let's take a look at a slide film here on how magnetic tape is made.

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1. MAGNETIC TAPE MANUFACTURING

Magnetic tape is a plastic ribbon coated on one side with material capable of being magnetized. Its three important components are the plastic backing, the magnetic particles, and the binder which holds them together. The raw material for magnetic coating is Ferric Oxide Hydrate, FE203H20, also used in making paint pigments. However, for magnetic coating, size and chemical purity are closely controlled.

The first manufacturing step is to remove the one molecule of water, resulting in alpha ferric oxide. While this is in a very stable state, the material is not yet capable of being magnetized. The alpha ferric oxide is then subjected to a reducing gas, either hydrogen, carbon monoxide, or water gas to produce this black oxide, commonly called magnetite. It is now magnetic, but has two major drawbacks. First, it has continuing oxidizing reaction. It still wants to rust. Second, tapes made from it have a recurring magnetic memory. Erased recordings tend to come back making later recordings noisy. These faults are eliminated by reducing the material back to a ferric oxide state through a special heating process. In this form, gamma ferric oxide, the material is now stable without the rusting characteristic of black oxide. It also has retained the ability to be magnetized.

The particle size of gamma ferric oxide for most magnetic coating is about one micron in length and about a length of that in diameter. Some newer oxides, however, have a particle size of just one third that size. Both the minute size and uniformity of size are important to smooth coating application and to control of the coating magnetic efficiency.

The binder used in the dispersion is likewise important. It is specially prepared to be compatible with the backing material to be used on the tape. It also has the durability demanded by the recording application the tape will serve. Binder and oxide are thoroughly mixed in large rotating drums which contain small metalic balls to help assure blending of the two ingredients. This operation, as well as the earlier oxide reduction process, is isolated from the tape coating and finishing steps to prevent coating from being contaminated by the oxide dust found in the air around these two steps. In fact, after a dispersion of oxide and binder has been thoroughly mixed, it is transferred to these large storage tanks and never again exposed to the uncontrolled, nonconditioned atmosphere. In each tank a large power mixer constantly agitates the blend to prevent premature hardening and provide proper oxide to binder balance. To guarantee getting the cleanliness needed for magnetic tape production and to house the especially developed types of coating equipment, the tape is produced in manufacturing plants designed exclusively for applying magnetic coatings. One is in Hutchinson, Minnesota. Another is located in Freehold, New Jersey and a third in Camarillo, California. This assures prompt delivery of tapes to tape users in all parts of the country.

In these plants separate air-conditioning units, one for each tape coating area, prevent dust from contaminating production. They operate on positive air pressure that moves the air away from the coaters, never toward them. Automatic vacuum door mats at each entrance remove the dust and dirt from shoes as further protection. Special air-locked double doors keep unsettled dust from entering critical areas. All personnel who work near the tape during manufacture wear special lint-free clothing. While the need for these precautions is most important during the time that the coating is still wet, they are found as well in all parts of the process to guarantee completely uncontaminated tapes.

In the slitting operation each jumbo roll of tape is slit to one of the tape widths needed in the particular recording uses for which the tape was made. Before each roll of tape is packed for shipment, it is vacuum cleaned as it is placed in the box, then exposed to a powerful electro magnet located just below package conveyors which erases-degausses-magnetically cleans each roll of tape.

The many sizes and types of magnetic tape found in this vast warehouse have undergone a manufacturing process based on the one you have just seen. However, each different tape, since it is built for a particular recording application, has it's own set of manufacturing specifications. Specifications based on the frequency to be recorded, the speed of the recording system, environmental conditions and other important recording characteristics in the many different tape uses.

2. BACKING SPECIFICS

Early tape recorders, while they were revolutionary and highly advanced in their day, would be considered obsolete when compared to the present day recording equipment. For such early recording equipment, paper backing materials were used and were good enough, no less dependable than the equipment. The tough, thin paper was flexible and readily available at low cost. But as equipment improved and recording techniques became more accurate, the physical and magnetic demands on tape became likewise more critical, bringing out several disadvantages of paper backed tapes. Paper's low strength factor limited the speeds and tensions that could be used in the system. Also, humidity caused paper to expand and thus be further reduced in strength.

While several plastic materials were researched, the first one to be found satisfactory as a backing material was cellulous acetate. Compared to paper, it was many times stronger and offered a very smooth coating surface. Finding the right binder to bind the oxide to the backing was one of the first problems in making plastic back tapes. Because of the radically different physical properties between plastic and paper, a binder had to be formulated which was compatible to the particular plastic backing being used, possessing the same aging properties, the same reaction to temperature and humidity, the same wear resistance.

If the backing and binder expanded at different temperature for example, tape tended to cup. This held the tape away from the head and reduced the output, especially at higher frequencies. This major problem was soon solved and cellulose acetate backing proved dependable and economical in many applications--applications which are less critical from the standpoint of temperature and humidity or in which extremely fast tape transport speeds are not necessary.

But for more critical tape uses like telemetry and other aero-space applications, where difficult and varying conditions exists, or where high speed transports generate frictional heat, base materials are made of a very durable, precisely manufactured polyester formula. Polyester backings have excellent dimensional stability, are virtually unaffected by atmospheric changes, and therefore can be used in recording applications where high humidity is prevalent. Polyester also has very favorable tensile strength characteristics, important to tape wear ability to high speed recording applications. Still another unique feature of polyester is its elastic memory. When the tape is stretched less than it's yield point, in other words, less than 5% of its length, the tape will return to its original shape, something many other backing materials won't do.

Determining which backing material should be used for a particular recording application, depends on the requirements of each application. In one, the strength of the backing material might be important. In another, tape stretching or breaking points, or heat and humidity characteristics might be the prime considerations. This chart compares backing materials as to stretch, yield point, and tear strength, three of several considerations important in selecting the proper tape for an application.

As with all tape components, projects or improving present backings and finding newer ones are the assignments of 3M research people. All kinds of materials are tested for stress, friction and wear properties, for their ability to withstand temperature and humidity changes, and for the overall compatability in being manufactured into a tape for specific recording applications. The different combinations of cost advantage, resistance to tearing or breaking, temperature and humidity, provide the tape user with a variety of benefits to be considered when ordering tape for a specific application.

3. COATING SPECIFICS

Different recording applications require different values of tape coating properties. Some require minimum wear, others the best possible output, still others high frequency response. 3M magnetic coating research has developed magnetic dispersions which provide tapes capable of increased values of all favorable characteristics.

One advancement that has increased the magnetic values of all coatings is a manufacturing step which takes full advantage of each magnetic particle. Early manufacturing applied the oxide as smoothly as possible, but with no regard to the relationship of one oxide particle to another. Now, by exposing the freshly coated dispersion to the field of a powerful electro-magnet, the particles are aligned or oriented in one direction. Aligned along the tape for most applications, but across the tape for the vertical scanning of some video recording.

Orientation increases output and results in a better signal or noise ratio. The increased output partly results from the fact that more oriented particles can be packed in a given area. Like a pile of toothpicks which are not evenly aligned, few unoriented particles will fit into a specific space in the coating. Oriented particles, like neatly aligned toothpicks, are more greatly concentrated in the same space.

Another coating requirement is uniformity of coating thickness more critical in some applications than others. Uniform thickness is important to uniform output, particularly when dealing with long wave lengths. Since the best output from a tape occurs when enough record current is used to completely saturate the coating, thickness variations will cause variations in output. Simply leveling the coating doesn't do the job, because of possible irregularities in the thickness of the backing across the width of the roll. A blade leveling technique would allow some areas to have a thicker coating than other areas. While this picture is a gross exaggeration of backing variation, it can be seen that a controlled coating thickness is important to uniform output.

To prevent variations in coating caliber, an exclusive coating process was devised by 3M engineers which applies precisely in the same thickness of dispersion, regardless of backing material variations. With this highly precise application technique, coating as thin as 100 microinches would be held to thickness variation of just 10 microinches.

Signal losses or agglomerate of oxide which stick to the coating surface protrude above the tape surface to cause an error in output, not just in that spot, but since it holds the tape away from the head in a much larger area around the spot. This umbrella effect is especially detrimental in recordings of closely spaced pulse or short wave lengths and to multiple track recording, since the affected area often covers several tracks. It is most detrimental in broadcast video recording where the vertical recorded tracks are only 5000th of an inch a part. This is why with video tape and with every magnetic tape 3M makes, every precaution is taken to assure absolute cleanliness during manufacture.

Coating errors and foreign particles on tape become more serious as slower tape speeds are used. Slow speeds mean reducing the tape wave length of a signal so that an error affects a greater portion of an

entire wave length. Because of the trend toward slower tape speeds in many recording applications, the highly protective cleanliness and coating application controls are constantly being improved to assure dependable recording results regardless of tape speeds.

The binder in a coating is likewise important to coating perfection. It must flow smoothly to permit even application. It must have a controlled drying time compatible with the time it takes to apply the mixture to prevent the forming of oxide clumps or agglomerates. It must also be able to supply that durable and flexible bond between the oxide particles and backing to give the tape a long usable life.

If a binder is durable, but also brittle, the oxide is in danger of being rubbed off. This again, is most visible in broadcast video applications, where the rotating heads penetrate the coating at 57,000 times a minute and at a pressure of about 10,000 pounds per square inch. Finally, the binder must have the same temperature coefficient of expansion as the backing. Differences in expansion between the two can cause the tape to cup, preventing good head to tape contact.

These many magnetic tape considerations; coating thickness; coating defects; durability; smoothness; temperature are basically important to the production of all magnetic tape. But they differ in importance according to the applications a tape will eventually serve. That is why each manufacturing run is controlled by specifications developed for a specific type of tape and specifically used.

4. MANUFACTURING QUALITY CONTROL

Magnetic tape manufacture is actually three processes in one: Manufacture of an oxide according to the specific needs of a particular tape application. Manufacture of a system of binder ingredients with those same specific needs in mind. And the combining and coating of those two components onto a specific backing material, according to a specific degree of smoothness dictated by that particular tape application. For this reason, control of quality cannot be simply a sorting system grading tapes into quality groups.

The tape you use must be designed specifically for your recording application before production ever begins, because tape requirements differ with the many different types of recording processes. The testing for a tape construction actually begins before its production ever starts. The raw material for the oxide is not accepted for manufacture until a test sample has first been completely processed into finished oxide, then hand coated onto a backing and tested to see if it has the properties needed in a particular recording process. The sample taken from each new batch of raw material undergoes the same reduction steps as a full kiln of oxide and the results compared to established standards to assure magnetic efficiency, correct particle size and chemical purity.

To guarantee that each kiln-load of oxide meets the rigid standards, close control is maintained of the heating time, temperature and reducing gas atmosphere in each reduction step. Constant inspection and adjustment, much of it electronically accomplished, periodic spot checks and additional hand coated test samples take the guesswork out of assuring uniformity of oxide manufacture. During the blending of these ingredients into a dispersion, both temperature and mixing time are closely watched to assure thorough mixing, with still another hand coated test sample made as a final magnetic check.

The backing material for tape, like the oxide raw material, undergoes a rigid pre-inspection to determine smoothness, maximum strength, uniform caliper and general quality. Backing thickness tolerances are held to 4% of the materials thickness. That's about 40 microinches on one mil tapes. These tolerances, checked on special electronic thickness gauges, apply not only to overall thickness of the material but also to the maximum variations in thickness allowable across the web of material.

Probably the most critical and most controlled part of the entire manufacturing process is in applying the dispersion to the backing. Using a strict program of quality checks, the sensitive, exclusively designed coating equipment applies the thin oxide coating within tolerances as close as 10 microinches.

If the construction is to be an audible range tape, it's properties are checked on the equipment typical of the professional audible range recorders used in the field. By making the sample into a loop and running it on test equipment the tape can be checked for magnetic efficiency and physical durability as well as surface smoothness and coating uniformity.

Once the jumbo roll of tape passes the rigid magnetic and physical uniformity checks, it is then cleared for the tape slitting operation where a new kind of quality check comes into play - the job of assuring cleanly slit, perfectly aligned tape edges. As each set of slitting knives is set in the slitting equipment, slitting samples are then checked to assure accuracy before proceding. Samples from each tape run are then sent to a laboratory for testing on standard recording equipment typical of the recording gear on which the tape will eventually be used.

Here tapes for instrumentation or computer use are tested on equipment typical of field operations, with any defects electronically counted to make certain that tapes meet the strict efficiency tolerance for these uses. By testing tapes on the same types of equipment used in the field, the eventual use of the tape can be perfectly duplicated and its expected performance accurately measured. Video tapes for example are tested on video recording equipment commonly used in television stations, the equipment for which the tape was developed.

Finally, packaging precautions - depending on the type of tape and its eventual use includes special center supports on big reels, seen here just behind the reel hub to protect the reel flanges from damage. Other wrappings or cartons have space between the reel and outer surfaces as further protection. For protection against moisture some tapes are sealed in a protective plastic bag before being put into the carton. The thorough precise quality control program developed through laboratory research and well over a decade of experience in field applications is the undisputed watch-dog of tape manufacture. Its demands on tape perfection increased in proportion to the ever growing demands for accuracy in new recording applications.

Mr. Humphrey

Thank you very much Mr. Devitt and I hope that you will thank 3M when you get back home for having participated so nicely in our program. We have as our next speaker Mr. William I. Hutton of IBM. Mr. Hutton has been involved in the magnetic tape recording field since 1947. His college background includes both Nebraska and Colorado Universities. He has served as a broadcasting consulting engineer and as Vice President of a commercial recording corporation. His first assignment with IBM was at the Poughkeepsie Center in the field of advanced machine design and development. For the past ten years Mr. Hutton has been manager of the Engineering and Field Services at IBM Minneapolis Magnetic Tape Center. Mr. Hutton will discuss the testing of computer tape for us.

William I. Hutton
IBM Corporation

Members of IRAC and Mr. Humphrey, it is my pleasure to be here this morning representing IBM and to give you a little background on your meeting subject, the care and feeding of magnetic tapes, specifically from the standpoint of the computer and the computer user.

To many people, the magnetic tape is looked upon as an incidental item to be handled much the same as we do other information media we use, such as paper and pencils. To those of us who are intimately involved in the economies of the computer operations, the magnetic tape is considered as an integral part of a computer. Actually it's equally as important as any component that we have in the system. For an example, the failure of a magnetic tape to be written on or be read back will cause us a loss of valuable system time. And this loss, of course, will be just as surely a failure as it would have been if there were electronic components or mechanical components in the system that would have failed. As many of you are aware, the loss of computer time is expensive and in

many cases the time lost cannot be made up because of the tight schedules you have for your equipment. Actually this may result in added expense in that you may have to go to an outside facility.

The cost of error failures can exceed many times the price of a reel of computer tape. Any reliability that can be tested into the tape prior to its use on the computer is a savings for the customer. In order to be constantly aware of the present and future requirements of magnetic tape and to establish methods of identifying and measuring these qualities, the IBM Magnetic Tape Center is continuously working with Tape Drive Engineering and Development as well as Systems Engineering Development people in our various laboratories.

Basically, the requirements that we are concerned with are the reliability and the compatibility of a magnetic tape—reliability when used in a given system, and compatibility when it's used interchangeably among systems.

To show you the importance that IBM places on the quality of magnetic tape, I will outline for you and give some examples of the operations that are performed at our Magnetic Tape Center and product testing facilities.

At the Tape Center, our primary testing operations are divided into two classifications.

1. Specification Testing - to determine whether or not each production lot of tape will meet the IBM specifications for magnetic tape - computer use, and

2. If the production lot passes the IBM specification test, then, Hundred Percent Testing of each and every reel that makes up this lot. Here we accept only those reels that can pass four additional writing and reading tests.

In our specification testing operations we make a total of 21 tests. Each of these tests was designed to measure one or more of the perimeters that we at IBM feel are essential to the operation of the computer itself. It is quite important that the measurements obtained in each of these 21 tests be within their prescribed limits, for the state of the art is such that the manufacturing process cannot be controlled to such an extent that it can be relied upon to always produce tape which will meet the specifications. When they do not, the end results can be a tape whose characteristics will differ considerably.

The chart we have here lists the specification tests we make. One of the tests listed is a measurement of friction. This measurement will give us an indication of the starting and stopping as well as wear characteristics of the tape surface. All have a direct bearing on tape reliability. As an example, the tape must go from a stop condition to a speed of 112.5" per

SPECIFICATION TESTS

SELECTION BY SPECIFICATION TESTING ASSURES BASIC REQUIREMENTS FOR LONG TERM RELIABILITY

21 PHYSICAL, ELECTRICAL & MAGNETIC TESTS MUST BE MADE

- WIDTH
- THICKNESS
- RESISTANCE OXIDE
- ROUGHNESS BACKING
- ROUGHNESS COATING
- FRICTION COATING TO BRASS
- FRICTION COATING TO RUBBER
- FRICTION COATING TO BACKING
- ADHESION COATING TO BACKING
- CURVATURE
- CUPPING
- ELASTIC CHARACTERISTICS
- YIELD FORCE
- CREEPOCITY
- WEAR OF TRANSPORT
- START TIME
- Ø-H PROPERTIES
- TOXICITY
- FLAMMABILITY

- QUALITY RETEST
- ADHESION LAYER TO LAYER

100% TESTS

ALL REELS

FINAL *100%* TESTING
OF EACH REEL PROVIDES
DEFECT FREE TAPE...
4 SEPARATE TESTS
MADE THE FULL LENGTH
OF EACH REEL

- *DYNAMIC SKEW*
- *SIGNAL LEVEL*
- *SIGNAL DROPOUTS*
- *NOISE*

second in a few milliseconds and maintain this speed without variation. A high friction characteristic would have an adverse effect on the acceleration. You might look at the movement of tape the same as the movement of the platen on the typewriter. If it were to go at various speeds, the typed information would be spaced irregularly. Of course, in the case of a typewriter you might be able to read it. On the computer, it would be impossible to read because computer logic allows only a limited period of time for each character. The start stop time and the speed of this tape must therefore be quite rigidly controlled.

To give you an idea of the amount of force that is placed on a tape as it is accelerated with a capstan, we can use a familiar measurement in terms of gravity or G. As an example, when an astronaut or flier. When he is subjected to from 5 to 10 G's will will black out. With forces of 15 or 20 G's most planes used today would lose their wings. As a contrast, when we start a tape from a dead stop we are applying 500 G's of force. The tape must be able to withstand this tremendous shock and those qualities that might affect acceleration such as friction, must be watched very closely.

The adhesion, layer-to-layer is another area that we watch very closely. This adhesion can be adversely effected by changes in pressure and temperature. Pressures can change due to varying winding tensions on a tape drive and temperature can vary during use and storage. Layer-to-layer adhesion, therefore, must be checked quite closely to see that it does not cause failures during the use of tape as well as the long storage use of tape.

Another characteristic checked is the long length durability. This is a check of the quality of the tape as it is used in a system under multiple pass operations. For this we use a test that we call a 200 pass test. During this test we write and read on a tape for a total of 200 passes, monitoring at all times for any temporary errors and permanent errors. And at the same time we will be printing out with electronic instruments the amount of time it takes to start this tape, bring it up to full speed, and stop it. At the end of the 200 passes we will inspect the tape contact points on the tape drive for excessive wear caused by the tape. In addition we will retest the tape that was used to determine if there were any unusual wear product build up on the tape during the long term test. This is a very important test because a single pass on the tester could not reveal the manufacturing variations that would effect multiple pass usage of a tape.

If all of the lot samples, have passed the 21 test, then we accept the tape for a second step. This is called 100% testing, where we test each and every reel individually throughout its usable length. Here there are four tests that must be passed by each reel of tape. A failure to do so will cause a reel to be rejected. One of these four tests is called a signal level test. Here we monitor the average signal level or strength of the magnetic field recorded on the tape. This is done to be sure that

the tape will produce a constant signal within prescribed limits. Any variation in the tape signal outside of these limits causes the tape to be rejected. Controlling this value allows the IBM tape to be used interchangeably throughout remote installations, without requiring machine adjustments. As an example, the various agencies send tapes all over the country and, of course, businesses do this too. If we can closely control the signal level, changes to the equipment will not be required when the tape is used interchangeably between remote locations.

Another 100% test that is made is one of checking the amplitude of each individual pulse. This is done to be sure that you can properly write on each possible information position in the tape. In this test, if a signal should fall below a prescribed amount, the tester will stop then on error. If this imperfection cannot be removed then the tape, of course, will have to be rejected. This test is similar to taking a punched card and punching out all of the possible punch positions then verifying that you can read them all. In other words, we look at every bit position on the tape, verify that it can be read with a good safety factor. To give you an idea of the magnitude of this test and the way that it is continually growing more demanding as the writing density increases; we began testing back in 1955 at 200 bits or characters per inch. This amounted to checking over 40 million individual positions that could be written on a 2,400 foot roll of tape. Each and every one of these spots on the tape has to be checked to make sure that they could be written and read properly before we could accept the tape.

Starting with 200 bits per inch, we have since moved up to 556 bits or characters per inch where we tested over 112 million character positions, then to 800 where we tested in excess of 160 million and now we have added 1600 bits per inch where we are actually looking at and verify throughout the length of tape, over 415 million individual magnetic spots. You can see by these numbers, a test such as this is quite a rigid one. It has to be for we certainly don't want to have a computer failure that will leave a man up in orbit. Businesswise we are also quite particular. A failure could change the location of a decimal point. As you can see, each and every one of these bit positions is important.

The third test is the noise test. This is a test that is made to detect any magnetic variations that might occur on the tape due to manfacturing faults. These must be detected and removed as they will cause false information spots on the tape. In this test we also stop on error and examine the area. If we can remove the defect we will do so. If not, then the tape would have to be rejected. This test would be similar to passing an IBM card without any punches through a verifier and verifying that there are no punches on the card. If there were to be a spot or hole on this card that you could read as information of course you would want to dispose of it. We do the same thing with magnetic tape.

The fourth test is one that we call a skew test. This is a test where we monitor the timing of the pulses on the outermost, or tape edge tracks. Should this timing vary and go outside the prescribed limit, it indicates that the physical characteristics of the tape in this area will cause it to guide improperly. This condition cannot be corrected. It is a guiding problem and, of course, there is nothing you can do to correct the guiding condition of magnetic tape, so it would mean that we would have to reject it. Going back to IBM card analogy again, this condition could best be described as one you would experience if you were to try to pass a card through a reader diagonally. It is impossible to do. The columns would be tilted and you would not be able to read the information properly. You would be reading parts of several columns instead of one column. We have the same problem with magnetic tapes as we go to these higher and higher densities. Any change physically as it goes through the guiding points would cause you to read the information improperly. We call it skewing. As an example of the sensitivity of this test at 800 characters per inch density, if the tape were to be moved .057 degrees, which is extremely small, this is all the movement that is necessary to cause us to go into error with the type of equipment that we are using.

We would like to add here that all IBM products have to pass a rigid test in what we call our IBM products testing laboratories. This, of course, applies also to our magnetic tapes. The type of tape that we select for IBM use must qualify in these labs before it can be used on IBM equipment.

The product testing group is a separate entity within IBM and, of course, is very impartial as it is responsible for the total overall operations of the systems. The tests that they give are very rigid and can take up to 8 months or more to determine all the characteristics required on a given magnetic tape construction. The tape must pass tests on all types of tape drives that are manufactured by IBM and that a customer would have in his installation. This is the only way that we can be assured that the user will have the compatibility required of todays tapes that are shipped and used interchangeably between remotely located installations.

After we have delivered what we feel is the finest computer tape possible, there are some precautions that should be taken when using magnetic tape. During use, the tape is subject to wear product and handling contamination as well as handling damage and machine damage. By contamination we are referring to the accumulation of wear products, room dust, and the general handling contamination that can build up either on the tape itself from handling or on the tape drives mechanism then transfer to the tape. Cleanliness of the system, cleanliness in handling the tape and periodic cleaning of equipment is quite important in keeping this contamination to a minimum.

Handling damage consists mostly of damages to the edge of the tape from squeezing the flanges of the tape reel. Damage to the tapes edges will prevent it from guiding properly. Information that could be written near this edge could not be read properly.

Never place the tape in such a position that it is needlessly exposed to room dust. As an example, never place it on top of a tape drive where it is hot and dusty and do not leave it open outside of its case on a table for an extended period of time. Any of these actions that would allow excessive room dust products to accumulate on the tape will cause the tape to be reduced in its reliability. There are a number of specific handling and use procedures that should be followed quite closely in order to maintain the accuracy of the tested IBM tape once it is delivered to the customer. Now I believe that the handling and use of tape within the system will be covered by the Colonel so I'll stop at this point and again thank you for your invitation and we've enjoyed speaking with you today.

Mr. Humphrey.

Thank you very much Mr. Hutton. The third speaker on our program will be Colonel E. C. Laedtke. Colonel Laedtke is presently assigned to headquarters USAF as Chief, Data Processing Division, USAF Data Services Center, operating in the Pentagon.

After entering the Army Air Corps he became a command pilot. During World War II he was a B-17 pilot in Europe flying with the 8th Air Force. During the Korean War he flew logistics support for Japan and Korea. Since 1946 Colonel Laedtke has been associated with the Air Force Controller, the major specialization in the automatic data processing area, with duty assignments at all levels of command. Data processing experience began with punch card accounting operations and today encompasses the management of 9 electronic digital computers. Colonel Laedtke is a graduate of the University of Maryland. He has had graduate work at George Washington University and is a graduate of the Air Force War college in Alabama. Colonel Laedtke will discuss the use of tape as records.

Colonel E. C. Laedtke
Headquarters USAF Data Service Center

I will cover three points briefly. First, magnetic tape as a document. Second, advantages of using magnetic tape as a document. And third, disadvantages of using magnetic tape as a document.

Let's now look at tape as another form of a document. How many of you have home recorders - stero-tape minded? Quite a few. Well, the tape we use in a digital computer operation, although different in size and better in quality, performs the same function for us on a computer that your tape does for you in your music system. Music on your tape at home is made possible by magnetizing spots on the oxide covering which was explained to us earlier. In a computer operation it is the same thing. Magnetizing of different spots on this tape gives us our numbers and our letters which the computer recognizes. There is a difference though in how fast your home recorder will pass tape as compared with a computer. A present day computer tape unit will move tape much faster than could ever be accomplished on a home recorder system.

In thinking about magnetic tape as a document I would like to run through briefly, the steps normally required before the manual records in your offices are represented in another form on a one-half inch or three-quaeter inch piece of tape. First, before you can take a document and say, "I'm going to place it on magnetic tape, and I'm going to get a computer to do my work," you must sit down and organize your data and plan on how you will use it. Too many people even today, after approximately 15 years of computer experience to reflect on, still fail at this first very important point of organizing information so it will go on the computer in an efficient and effective manner. Many offices will automate, things will go wrong, they will blame the computer and they will blame the tape. Really they are blaming a fault in their thinking in that very early step of organizing their records so that they can be mechanized. This then is the first important step for you to consider.

Now let's assume we have accomplished our initial planning and know what we want. We have our fields of information decided. We have some of these fields coded, possibly. We know just what we are going to do. Now we have to get those manual records on tape. To do this we go through a conversion process and I will briefly identify ways we do it today. A principle major method of getting that information from your office, from your filing cabinets, and onto magnetic tape is through the old fashioned card punch machine. This is still a big "number one" way of accomplishing this operation but not the only way. Today we also use punched paper tapes. Punched cards and punched paper tape go through another process we call "card-to-tape" or "paper-to-tape" processing in which this information is transferred to a reel of magnetic tape. Another way, and a relatively new way, is direct key punching onto magnetic tape. We do not use this latter method in the installation to which I am presently assigned because its use is limited by application. It has definite advantages if used properly and another way to get information from your filing cabinet to magnetic tape. Today there is also much experimentation going on in the optical scanning field, wherein a machine "looks at" your manual record and creates a computer record. I'm brushing over these very fast and want only to identify this transition step.

The question usually asked at this point by those not too familiar with data processing is "How many of my records can I put on a certain length of tape?" There is no single answer to this question. It depends on how long your records are, how many characters of information you use, and how tightly you press these characters together on tape. For example, over in the Pentagon today, on our particular tape drives we can put information on tape in three different densities...200 characters to an inch, 556 characters to an inch, or on our later drives, 800 characters to an inch. Certain equipment manufacturers provide capability for even greater densities. Density means more if we site an example: Consider a density of 800 characters of information to an inch. An 80 column punched card....the kind you are familiar with....can be reduced to 1/10 of an inch of magnetic tape. So you see you can handle a great deal of information on a single 2400 foot reel of tape.

We now have this information on tape...what next? We now enter the field of "tape handling", and one very important step must be accomplished. This is the labeling of the tape reel at the time our information is placed on it. You know at home how you can "goof-up" your library if you mis-name or mis-label a particular reel. In computer processing work, the same danger prevails. So we follow a very strict procedure called "tape labeling" which can be initiated either in the data processing installation or back in your office. A new procedure we instituted in the Pentagon recently is one that requires the customer to prepare the tape label and send it to us together with their processing request. We of course distribute detailed preparation instructions for completing the label. Such advance preparation can't be done in all cases, since there are times when the customer really doesn't know in advance certain of the identification items required by the label. We find this system very helpful and it has decreased the number of labeling discrepancies. You might ask, "What identification and control items are found on a tape label?" This varies by organization but the common items include the name or title of the particular data recorded, the number of the reel, the "as of date" of this particular information, the customer's code or name, an all important data retention date, the security classification assigned and the character density at which the reel was created. As I said, the specific items used vary by installation and the method of magnetic tape inventory control employed.

Your data is now recorded on magnetic tape and is ready for filing in what we commonly call a tape library. A tape library is very similiar in many respects to a book library. You have your racks and filing sequence which must be followed religously. We in the Pentagon, for example, at the present time have approximately 25 thousand reels in our Air Force Library. Twenty-five thousand reels is classed as a very substantial library, but number of reels by itself is really not the all important factor. Your tape activity is of upmost importance. "How often to you withdraw and refile a tape." This is tape activity and we have great activity. For example, on a typical day over in the Pentagon, servicing the Air Staff of the Air Force and Mr. McNamara's office, we utilize on an average day anywhere from 600 to a 1000 reels....sometimes it even exceeds 1000.

Your records are now on tape, filed in a tape library, and ready for future processing. Now what are some of the advantages of having your records in this new form? Briefly let's go over a few of them: First, one I mentioned earlier....the compact filing. You can eliminate numerous filing cabinets and end up with several reels of tape which is certainly a space saving advantage. Then, you have flexibility of use. Previously you had to thumb through your records to find something. Now you have it on tape and through computer processing techniques we can search for, discover, sort, compile, calculate and printout whatever you want. The flexibility of use is really up to you....the customer. Once you have the data created, once such recording is accurate, once it is on tape there is no end to what you can do with it.

Tied directly to flexibility is of course frequency in use possibilities. Your now "mechanized" basic information can be used as often as you desire. You might ask "Can I wear out my tape?" Here again I don't think you will find anybody who will give you a firm solid answer, particularly if you are using some of the new tape on the market today. I will say that it is almost impossible to wear it out if you take care of your equipment, keep your tape heads clean and exercise care in handling. Then in the event something does happen you can always duplicate your reel by "copying" the data on a new reel. Let's also put "realiability" on our list of advantages. Once your information gets on the tape, it will never change unless you change it. This, I'm sure, you must consider a definite advantage.

Ease of shipment and/or transmission is another advantage. It is certainly easier to ship a reel of tape representing information in half-dozen filing cabinets than it is to ship the basic data. Also a new innovation of the past several years permits the transmission of your data to another location over the Defense Communication Systems Automatic Digital Network ....AUTODIN. This is a world-wide system wherein data from a reel of magnetic tape or punched card information can be loaded on an AUTODIN terminal and transmitted practically anywhere in the world and picked up on the receiving end as magnetic tape or punched cards. The information might have been originated by Burroughs-type equipment and received elsewhere in a manner permiting immediate use by -- IBM equipment. This is a flexible and rapid way of getting information from one place to another. In Air Force Headquarters we are today tied together, through AUTODIN, with all of our major Air Force commands world-wide and during an average month will receive and transmit in the neighborhood of 2 million data records.

Another advantage of having your records on magnetic tape is related to the output products from those records. Today you might have your record "mechanized" but are wondering what to do with all of the reports and listings that are printed from these records....in other words you are "snowed-under" with management documents that you desire to retain. Today there is a piece of gear available that will take this digital information direct from tape and, through a cathode ray tube connection and microphotographing techniques, photograph these reports for storage in the form of microfilm...an advantage.

Let's list "life expectancy" of your taped records as an advantage. For years we thought a taped record would last forever and many of us today still think that, under certain conditions, this is true. Since I had to think of some disadvantages to give you I'll turn this point around a bit later on and call it a disadvantage.

As a last advantage let's list security classification and declassification. In creating a magnetic tape reel we can classify it in whatever manner you, as the customer desire. It can also be removed at your request.

Declassification has been a rather recent innovation. It was only late in 1965 that the Department of Defense gave the military departments the "green-light" to declassify previously classified tapes. To accomplish this a reel is passed through a special degaussing or erasing operation, using approved equipment, and it again becomes unclassified. Before receiving this release permission the only way to declassify a previously classified tape was to completely destroy it by burning.

My third point this morning concerns disadvantages of placing your records on magnetic tape. As I said earlier it wouldn't be appropriate for me to only list advantages so I have come up with several items that could go on the other side of the ledger. Some of these might appear "doubtful disadvantages", and if you want to disagree with me you might not find strong opposition.

First, let's consider "ease of destruction". You have your file on tape, a file that you spent thousands and thousands of dollars accumulating and you want to keep it as such. This taped file can be very easily erased as those of you in the home recording business well know. Just take a soldering iron and hold it close over the reel and your data is gone. Or you can inadvertently, although you have to go out of your way to do it, write somebody else's information on your particular reel of tape. As I say, you have to go out of your way to do this because equipment manufacturers have gone to great lengths to keep operating personnel from inadvertently destroying your file.

Let's list the requirement for duplicate tape records as another disadvantage. We found that when you have magnetic tape files it's a good idea to have some duplicates...not duplicates of everything...but selected reels. I mentioned that our Headquarters USAF tape library contains approximately 25 thousand reels and we have our several hundred of these duplicated and filed in an alternate physical location. The Air Force learned its lesson back in 1959 when we tried to burn-down the Pentagon. I'm sure some of you remember that. That fire destroyed our entire tape library which, at that time, contained only 4 or 5 thousand reels. Many months were spent and thousands of manhours to recoup basic data files. So today we have selected alternate files... files our customers have selected as those requiring such protection. This additional precaution could, I suppose, be cited as a disadvantage of having your records on tape.

It might be well to list special tape handling as a disadvantage, but here I'm sure we will have disagreement. The requirement to exercise care in handling tape was touched on by Mr. Hutton and I won't repeat what he said. When handling tape you must exercise a certain amount of care in removing a reel from its container, in placing it on a tape drive, and finally in removing it and returning it to its case. But we in our installation have found out one thing about tape handling. Some of the handling precautions we thought years ago were ultra-critical to a computer installation, are not quite so critical. Dirt - surely, elimination of dirt is important and you should do everything possible to have a clean installation. You might remember that many of the early data processing

installations prohibited cigarette smoking anywhere near a computer.... even today many do not allow smoking. Some installations required that you don a white coat and clean your shoes before entering the computer room....that is if you were even allowed to enter. These precautions, although good, are extreme and no longer absolutely necessary.

In this area of tape handling I would like to cite an example. Last November we went through a major building renovation project over in our computer center, where six of our nine computers are installed. During this renovation work the Air Staff and Mr. McNamara didn't say "You boys close up shop". We were expected to continue producing in the normal manner, so even during the tearing-down and rebuilding we continued our operation. Part of the renovation involved removing the entire floor under the computer area. To accomplish this a very detailed timing schedule was worked out so a portion of our operation would be underway at all times. As we removed the old floor to put down the new one, we discovered dirt from the fire of '59 still underneath. In our particular installation, because of the limited floor space and the close placement of our computers we have a heat problem which is solved by having two air-conditioning systems. One of these blows the air in from underneath the floor and the other one from on top. So, when we took this old floor up and disturbed the packed dirt you can imagine what happened. We had more dirt in that computer room than I think any place in Washington. But we kept operating, and at the same time made it a special point to keep track of what we could identify as increased tape problems because of the disturbed environment. It might be difficult to believe, but our identifiable tape problems showed no increase.

In citing this example please don't take me wrong. I am not advocating or encouraging computer operations in an environment I just described. Certainly you should take whatever precautions are necessary, but I wanted to bring out that when using certain equipment you can continue processing under very adverse conditions....possibly I should have placed this item in the advantage column.

Another problem when your records go to tape, is of course the danger of using defective tape. As with almost every product on the market today there is good and bad....or good and not so good. To have effective and efficient data processing you must use good reliable tape because there is no end to the problems if you don't.

Another possible problem concerns storage of your taped records. Although the new tape that we are using today....heavy duty tape....is not as susceptible to humidity and temperature problems as some of the early mag tape used a decade ago, we still attempt to maintain certain temperature and humidity controls in the tape storage area. Such controls, although not as critical as for the data processing equipment itself, must still be within certain limits. In our installation we consider between 40 and 90 degrees fahrenheit on temperature and 20 to 80 percent

humidity as the acceptable ranges. True, a rather wide range here but still some control necessary. When a tape comes to us from an outside environment we like, if at all possible, to have it in our processing installation atmosphere for at least 24 hours prior to use.

Still another possible disadvantage might be the requirement for periodic tape rehabilitation. You can't just keep using tape over and over. At some point you are required to clean it and check it for defects, both of a temporary and permanent nature. There is special equipment on the market used in accomplishing this task and I won't go into this.

Now the last possible disadvantage, and one that could really develop into a true disadvantage, of using a tape record. But my personal feeling is that if it becomes a true problem, ways will certainly be developed to overcome it. This possible problem was brought to light by one of the civilian agencies of the Federal Government.....Social Security Administration in Baltimore. They reported at a recent magnetic tape user conference a difficulty in reading recorded information in the area of the reel hub if such a reel was stored for more than three months. A preliminary diagnosis seems to show a slippage of the adhesive used to hold the iron oxide particles, and consequently created a situation where the tape is unreadable. This is something new in our business.....something we have not identified as a problem in our installation.....to date anyway. Possibly one reason we don't is that we do not "pack" data onto a reel of tape in the manner that Social Security does. Usually our files end before we reach the hub area.....maybe if we were constantly using "fully-packed" reels we also might have a problem. We understand Social Security has solved or at least minimized this problem by running their reels through a controlled tension winding operation which establishes a constant tension as the reel goes through its rewind cycle. If it is a true problem rest assured it will be solved.

So.....There you have some possible disadvantages, and I put possible in "quotes". You might disagree with me on their classification and if you do I won't fight too hard to hold my position since my main objective was to inform. This morning, in a few minutes, I tried to tell you a short story about the use of magnetic tape as a record, and advantages and disadvantages of doing so. And when considering this subject there is one thing we should keep in mind.....mag tape records are here to stay. Improvements in data processing equipment will certainly continue as well as improvements in the manufacturing and use of magnetic tape. History demands the recording of information and today one of the best ways of doing this is through the medium of the magnetic tape. If your office, your agency, your activity is not "automated" today, rest assured that one of these days it will be, and you will then have a firsthand experience with the subject discussed here this morning.

Thank you ladies and gentlemen for the opportunity to be with you today.

Mr. Humphrey

Thank you Colonel Laedtke, I am glad for one that you took the extra time. It was very interesting.

Ladies and Gentlemen we will now have a brief few moments for questions and answers. Will you please pass your questions forward and address them to the speaker that you would like to answer. Mr. Devitt would you like to answer a couple of questions here?

Mr. Devitt

There are two questions here. One is - Some plastic reels have cracked or broken on the inside of the hub. Is this caused by storage conditions or improper mounting on the tape drive?

I think this could be caused by a couple of things. Also I think that which are coming up, instead of 50-60 million characters of information can now store in some of their components, hundreds and hundreds of millions of characters. Some people suggest that we store everything on these drums and not worry about tape. My personal feeling is that tape is going to be here for a long time and possibly in increased use.

Sure we can take your basic file. We can store it on a drum. We can process from that drum. We need not go to the library and pull out all these reels. But my feeling is, that if we get to that point in the Pentagon, we will back up those basic files with a reserve data file for security purposes. For history is another thing. Sometime you are going to clean these hundreds and hundreds and millions of bits of information and put new information on the tapes. So you will have need for historical files. Tape will be with us. You'll see it. If your office, your agency, your activity is not mechanized today, rest assured one of these days it will be. That is the way the push is going. Thank you ladies and gentlemen for these minutes with you.

Mr. Hutton

My question asks: "Are you working with the group at GSA which is developing Federal Specs for computer tapes?" This is true, we have representatives sitting on almost every committee that is involved in this matter so that there can be a cross referencing of ideas as to what will make a computer work the best. This is our primary reason for being in the tape testing industry today. We are most interested in what will give you the greatest degree of reliability and accuracy on the computer.

I think this is a good group, this Federal Specs Committee and we do, of course, have a man with this group. I'm sure that there is a 3M man working with GSA developing Federal specs for computer tapes.

Mr. Humphrey

We are answering the questions in the order that the speaker had in the program. Colonel would you take - there are two there I think.

Colonel Laedtke

The first question asks "Would you trust keeping very important records for 50 years solely on magnetic tape or would you also keep the printout?" It's difficult to give a brief answer to this question since I'm not sure of the volume of printout that the gentleman was referring to. If the volume was small and you had the space I would say there would be no harm in keeping the printout. If such output products were large and space consuming, I would suggest looking into the microfilming possibility mentioned in my presentation. Then of course, if the records were very important they would almost certainly continue to be retained in magnetic tape form to facilitate possible re-use or recall in the future. Today we really don't know how long our new heavy duty type tape can be retained before it deteriorates....might be 50 years....or it might be longer. This is still one of the questionable areas in our business.

I have a little difficulty reading the second question, but I believe that the party is requesting information on how often should a tape be checked for "fade or possible deterioration"? I believe the party is possibly asking for information on how often you should check a reel of tape for possible defects. Some data processing installations accomplish this on a scheduled basis which requires each reel in the inventory, after the lapse of a certain period of time, to go through a tape rehabilitation cycle. During this rehabilitation the tape might be washed to remove all loose foreigh matter and then processed through a certification machine which will identify location and number of all defects on the reel at that time. Such a program might call for the rehabilitation of each reel on an annual basis....or it could be less frequent. Other data processing installations, and I include ours in this group, do not have a specifically scheduled program but accomplish a rehabilitation operation on an as required basis. In our installation it works like this: Whenever a computer operator detects what he believes is a defective tape he immediately prepares what we call a "suspect ticket" and attaches it to the questionable reel. In some cases a suspect reel will permit us to complete the particular run that is on the computer, and in such a case the reel with the attached suspect ticket will go to our rehabilitation section prior to its return to the magnetic tape library. Because of the number of reels in our inventory, and our somewhat limited rehabilitation capability, we make no attempt to periodically check reels which are not in a suspect category.

Again, I say, the program is up to the particular installation. But all installations should possess some type of quality checking capability. I hope I have answered this question to someones satisfaction.

Mr. Humphrey

Thank you very much Colonel. I want to thank all of you gentlemen for putting on our program today. It was mighty, mighty interesting. Ladies and Gentlemen we stand adjourned.

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